

UNITED STATES DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

TWO AUDIO-MAGNETOTELLURIC PROFILES ACROSS THE SYLVANITE  
ANTICLINE, IDAHO AND MONTANA

By  
1  
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This report is preliminary and has not been  
reviewed for conformity with U.S. Geological  
Survey editorial standards.

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## INTRODUCTION

The audio-magnetotelluric (AMT) soundings for these two profiles were recorded by the U. S. Geological Survey in September of 1982 near the Canadian border, northwest of Libby, Montana. The object of the reconnaissance AMT survey was to define vertical and lateral resistivity boundaries related to lithologic and structural features of the Sylvanite anticline. Thirteen AMT soundings were recorded at a station spacing of approximately 3 miles on two profiles. This survey was part of an ongoing study of the Belt Supergroup and Conterminous United States Mineral Assessment Program (CUSMAP), which included other Wilderness studies.

Earlier AMT studies (Wynn and others, 1977; Long, 1983) indicated that this resistivity method worked well in the Belt terrane of northwestern Montana for defining unknown lithologic and structural features. Theory and applications of the AMT method to reconnaissance surveys and mineral exploration have been described in detail by Strangway and others, 1973; Hoover and others, 1978; Long, 1983; Long, 1985.

## AMT DATA

This report presents the results of these data as scalar resistivities, at two orientations N-S and E-W, for each station (data log, table 1) and preliminary interpretation of two resistivity cross-sections derived from inversions of the AMT sounding curves using the (Bostick, 1977) computer algorithm. Figure 1 shows the location of the cross-sections and AMT station locations, figure 2 the implied resistivity-depth section.

The character of the two AMT resistivity sections A-A' and B-B' are somewhat different. AMT section B-B' reflects high resistivities at a nearly uniform depth across the central portion of the anticlinal structure. These high resistivities would be expected from the dense rocks as indicated by the gravity high (Dean Kleinkopf USGS, written commun.) across this area, while AMT section A-A' indicates various resistivities and thicknesses across a similar gravity high to the north. The disagreement of section A-A' with known and projected geologic structures may be due to station location. The stations may be on or near large inhomogeneities. Overburden, large changes in topographic relief, 2 or 3 dimensional lithologic features and structural contacts are possible causes of the inhomogeneities.

Resistivities of  $>1000$  ohm-m on resistivity section B-B' outline the gross structural configuration of the anticlinal structure as described by Jack Harrison, USGS, written commun. The 1000 ohm-m contour, between stations 9 and 11 (fig. 2) gives some indication of the thickness (approx. 12,000 ft) of the Prichard Formation and reflects a lower resistivity for basement rocks of an uncertain type in this area. Resistivities  $<1000$  ohm-m here may correspond to a basal surface that separates basement from Prichard Formation as described by (Dal Stanley, USGS, written commun.). The gently west dipping low resistivity beneath station 8, probably indicates the less dense, fractured or permeable (low resistivity) rocks of several intersecting faults to the east. The low resistivity ( $<630$  ohm-m) closure below station 13 may be related to the known conductive unit of the Prichard Formation (Long, 1983), which is a slightly carbonaceous argillitic unit containing pyrite or phryrrhotite films and disseminated mineralized zones.

The resistivities and depths of section A-A' from east to west are more descriptive of local boundaries than the overall configuration of the anticlinal structure. At station 4 a high resistivity (>1000 ohm-m) reflects the Revett Formation near the surface, but at depth shows a conductive zone as it approaches an intersecting fault zone (Jack Harrison, USGS, written commun.). Station 3 is also near a mapped fault contact that reflects low resistivity. Data from the AMT sounding number 2 (table 1) displays a large separation between the two orthogonal sounding directions. The separation in the two directions indicates an inhomogeneity, possibly a unmapped structural feature on a lithologic contact with a large resistivity contrast. Station 1 reflects a conductive zone (<1000 ohm-meters) which may be attributed to conductive overburden in the vicinity of a small lake. Conductive earth limits the depth of exploration and tends to bias the sounding and lower the resistivities for all frequencies. Therefore, the sounding may not indicate the higher resistivities that may exist at a depth greater than the depth of exploration. The resistivity section at station 5 reflects the largest resistivity change seen on both sections, and is probably due to its location near the north-south striking vertical fault mapped in this area. Station 6 shows uniform resistivity with no local structure nearby, gives a better average of the rocks true thickness and resistivity. Station 7 is near an implied crest of a folded structure and reflects a low resistivity unit below the surface capped by more resistive material.

The combination of geophysical and geological data for the two profiles across the major structures and lithostratigraphic units of the Sylvanite anticline significantly increases the vertical resolution of major structures in the subsurface. The match between changes in the resistivity depth section and inferred geologic units below the surface provides confidence for the interpretations of the subsurface.

#### References

- Bostick, F.X., Jr., 1977, A simple almost exact method of MT analysis, in Electrical Methods in Geothermal Exploration: Salt Lake City, University of Utah, Department of Geology and Geophysics, p. 175-177.
- Hoover, D.B., Long, C.L., and Senterfit, R.M. 1978, Some results from audio-magnetotelluric investigations in geothermal areas: Geophysics, v. 43, no. 7, p. 1501-1514.
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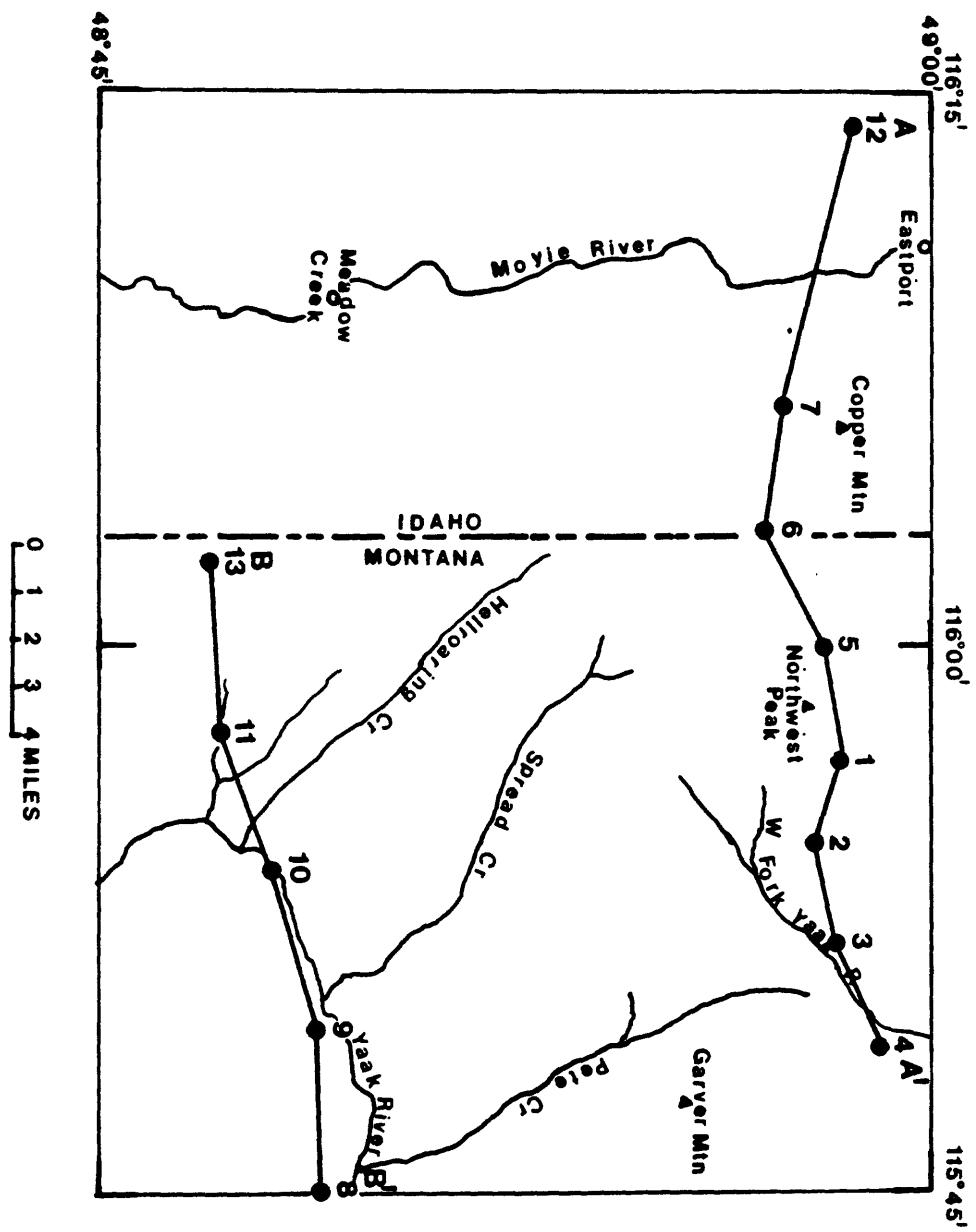


Figure 1.—Map showing station numbers and location of resistivity sections, A-A' and B-B'. AMT stations locations are indicated by solid circles.

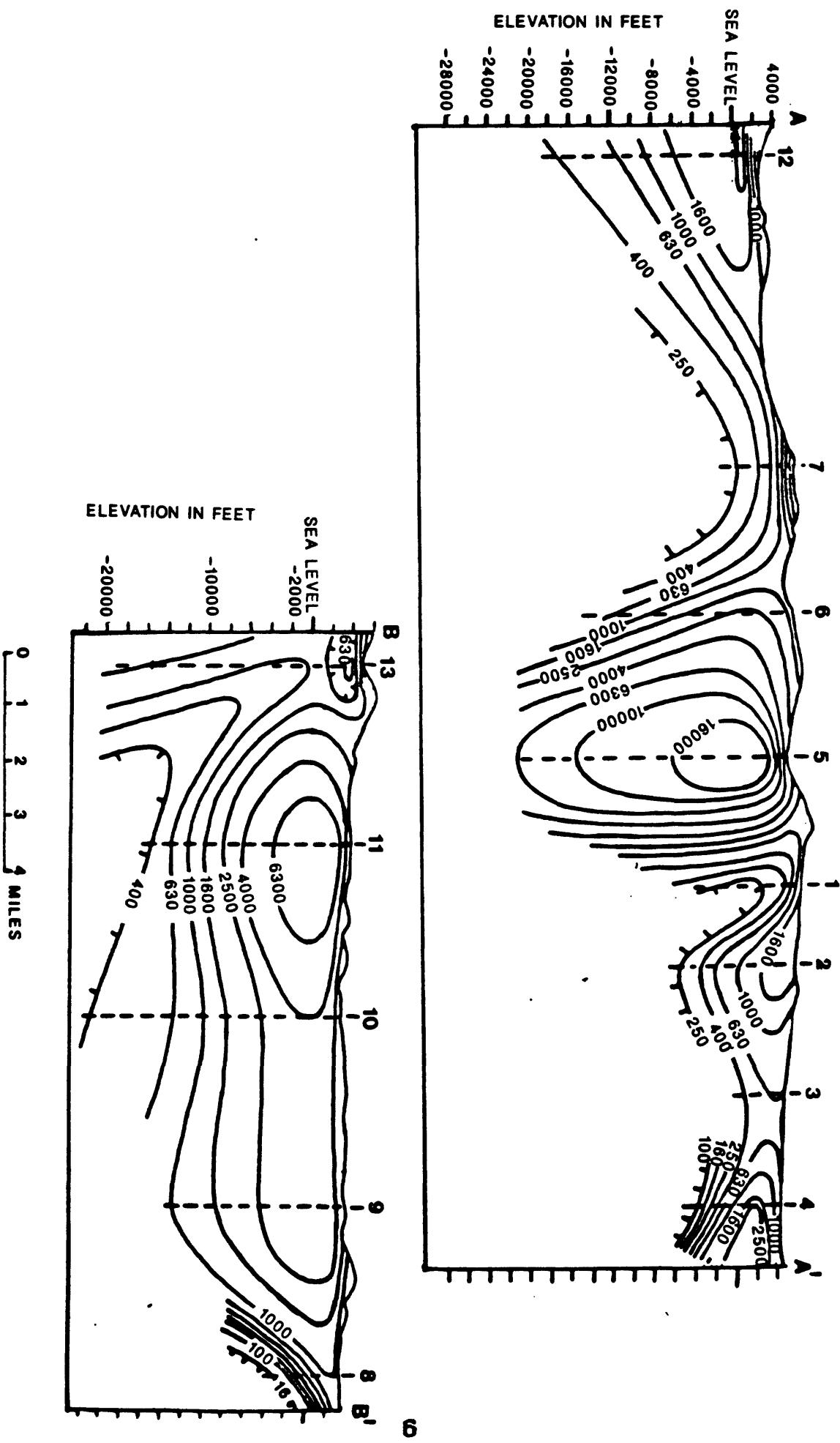


Figure 2.--Resistivity sections along profiles A-A' and B-B'. Resistivity

contours are five even intervals per decade of the LOG scale (i.e.,

100, 160, 250, 400, and 630) in ohm-meters. Hachures indicate low

resistivity.

Table 1 U.S. GEOLOGICAL SURVEY A.M.T. DATA LOG- 1982

## PROJECT=YAAK RIVER-----

STA. ID\_YAAK1 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	2384.70	5	1506.80
7.5	440.33	3	93.10
13.6	97.98	7	22.59
27.0	110.17	8	26.36
45.0	167.35	10	31.86
75.0	220.94	11	41.32
136.0	423.95	11	41.09
270.0	560.37	11	67.65
450.0	483.51	8	59.16
750.0	715.07	6	67.35
4500.0	2096.10	11	234.24
7500.0	2329.40	12	104.68
13600.0	3606.30	13	691.29
27000.0	896.51	5	35.74

STA. ID\_YAAK1 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	725.79	6	141.47
7.5	499.28	12	36.81
13.6	623.98	11	18.70
27.0	603.80	10	36.40
45.0	812.00	11	24.73
75.0	803.06	10	17.41
136.0	608.42	13	15.15
270.0	947.28	10	40.98
450.0	872.40	11	49.52
750.0	2089.80	6	299.56
4500.0	2514.50	10	395.73
7500.0	1087.80	11	111.26
13600.0	5928.20	13	1068.80
27000.0	873.74	4	13.02

## PROJECT=YAAK RIVER-----

STA. ID\_YAAK2 NS NO FREQ= 10

FREQ	AP-RES	N OBS	STD ERR
4.5	1666.00	5	229.83
7.5	2887.60	10	302.88
13.6	3601.60	11	306.88
27.0	011199.00	10	1246.20
45.0	6510.00	14	505.73
75.0	9036.40	12	1225.80
136.0	8536.50	11	1030.70
270.0	014295.00	13	1104.70
450.0	010419.00	12	815.07
750.0	7513.70	11	762.97

STA. ID\_YAAK2 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	839.36	8	186.00
7.5	143.81	11	15.36
13.6	125.55	10	9.69
27.0	143.19	12	11.43
45.0	175.37	11	7.84
75.0	217.60	11	6.18
136.0	166.94	12	4.21
270.0	310.94	13	10.57
450.0	344.43	10	16.07
750.0	373.16	11	33.34
13600.0	1673.80	11	92.44
27000.0	2075.20	7	384.91

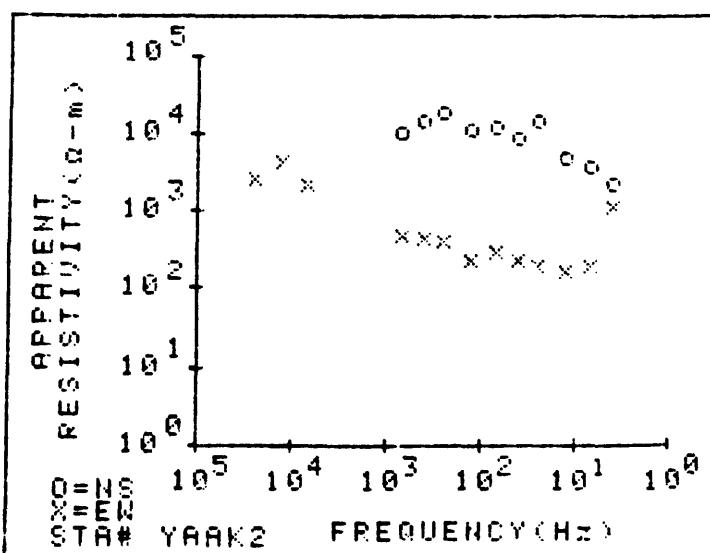
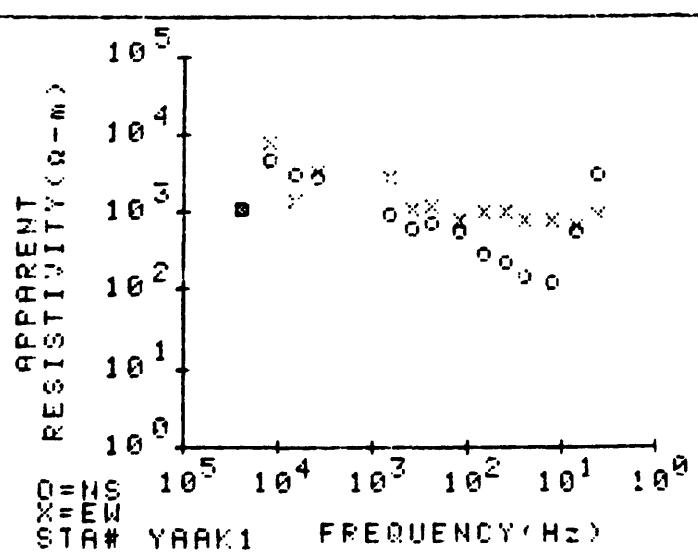


Table 1 U.S. GEOLOGICAL SURVEY A.M.T. DATA LOG- Continued

## PROJECT=YAAK RIVER

STA. ID\_YAAK3 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	468.68	4	175.18
7.5	159.67	9	15.75
13.6	161.51	10	24.96
27.0	170.46	10	17.52
45.0	248.47	10	18.52
75.0	213.44	10	15.27
136.0	142.50	11	7.32
270.0	328.10	10	29.79
450.0	236.56	10	17.16
750.0	172.80	10	3.01
4500.0	586.45	10	118.57
7500.0	475.49	10	14.56
13600.0	498.67	10	30.00
27000.0	447.24	5	20.52

STA. ID\_YAAK3 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	794.95	11	96.23
7.5	1002.60	11	74.46
13.6	992.81	10	49.43
27.0	1013.20	10	29.61
45.0	877.28	10	16.42
75.0	821.93	10	16.29
136.0	491.82	10	16.09
270.0	646.49	10	12.61
450.0	642.57	10	26.86
4500.0	521.88	11	71.51
7500.0	510.92	11	26.59
13600.0	498.02	11	31.41
27000.0	356.63	7	32.46

## PROJECT=YAAK RIVER

STA. ID\_YAAK4 NS NO FREQ= 10

FREQ	AP-RES	N OBS	STD ERR
4.5	210.85	10	12.94
7.5	390.13	11	16.49
13.6	505.45	15	20.62
27.0	815.10	11	21.33
45.0	999.30	12	30.41
75.0	1152.00	13	35.46
136.0	833.79	10	12.45
270.0	1260.00	13	20.11
450.0	1001.10	10	48.45
750.0	554.47	13	36.06

STA. ID\_YAAK4 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	189.45	7	25.39
7.5	259.33	10	17.89
13.6	521.46	12	45.41
27.0	959.17	13	63.73
45.0	1367.60	13	81.66
75.0	1934.30	10	127.30
136.0	1199.00	13	20.45
270.0	1429.10	13	72.99
450.0	752.55	12	72.19
4500.0	585.51	10	52.42
7500.0	616.12	13	95.69
13600.0	685.96	10	58.60
27000.0	540.93	7	17.11

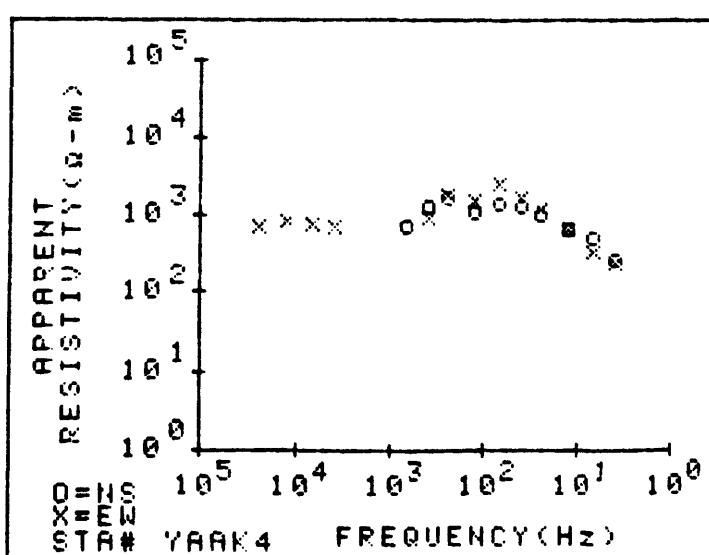
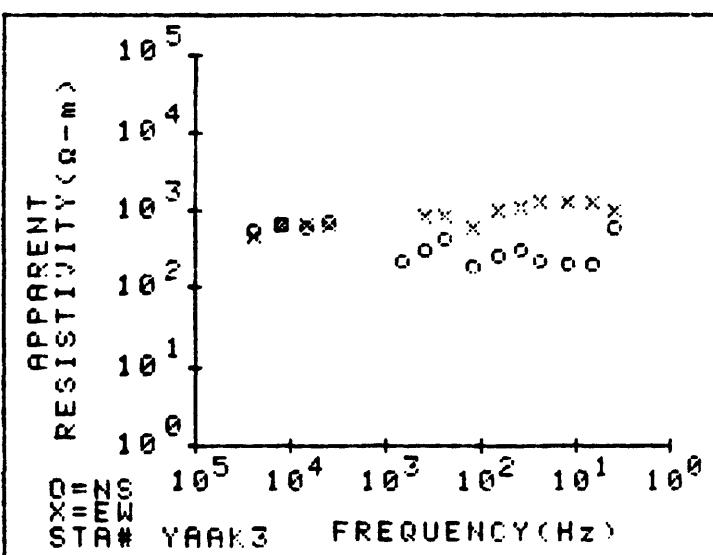


Table 1 U.S. GEOLOGICAL SURVEY A.M.T. DATA LOG- Continued

## PROJECT=YAAK RIVER

STA. ID\_YAAK5 NS NO FREQ= 11

FREQ	AP-RES	N OBS	STD ERR
4.5	1386.10	9	137.40
7.5	934.99	12	121.03
13.6	1646.20	12	225.95
27.0	3014.70	12	231.46
45.0	3340.00	11	280.53
75.0	4902.00	10	294.28
136.0	3681.40	10	134.52
270.0	6909.60	11	162.05
450.0	7644.10	10	411.42
750.0	8049.20	10	872.68
2700.0	759.31	10	97.89

STA. ID\_YAAK5 EW NO FREQ= 11

FREQ	AP-RES	N OBS	STD ERR
4.5	14680.00	9	2576.30
7.5	523543.00	10	648.59
13.6	623490.00	10	1314.30
27.0	25668.00	10	920.23
45.0	29759.00	10	981.44
136.0	25570.00	10	540.70
450.0	29434.00	10	1470.70
750.0	22810.00	10	510.16
4500.0	13521.00	6	4777.20
7500.0	5021.90	10	1028.10
13600.0	22085.00	9	6191.50

## PROJECT=YAAK RIVER

STA. ID\_YAAK6 NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	1338.40	10	261.76
7.5	1175.40	11	101.50
13.6	1791.70	10	129.93
27.0	2081.30	12	84.25
45.0	2554.50	10	80.71
75.0	2407.60	10	53.06
136.0	1428.10	15	27.02
270.0	2122.40	11	49.76
450.0	2027.80	13	44.82
750.0	1841.30	10	71.63
1360.0	1250.40	3	282.59
4500.0	836.39	3	191.14
7500.0	3358.50	13	393.33
13600.0	1793.90	11	261.39
27000.0	91.72	2	3.43

STA. ID\_YAAK6 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	751.76	6	98.52
7.5	1664.50	12	106.67
13.6	1475.50	11	45.44
27.0	1896.40	11	94.51
45.0	1714.50	12	70.40
75.0	1756.00	12	35.12
136.0	1089.40	13	37.69
270.0	1411.60	10	70.57
450.0	1418.00	10	100.72
4500.0	1084.20	8	151.71
7500.0	1083.30	12	78.44
13600.0	1689.90	11	178.08
27000.0	3895.80	3	81.98

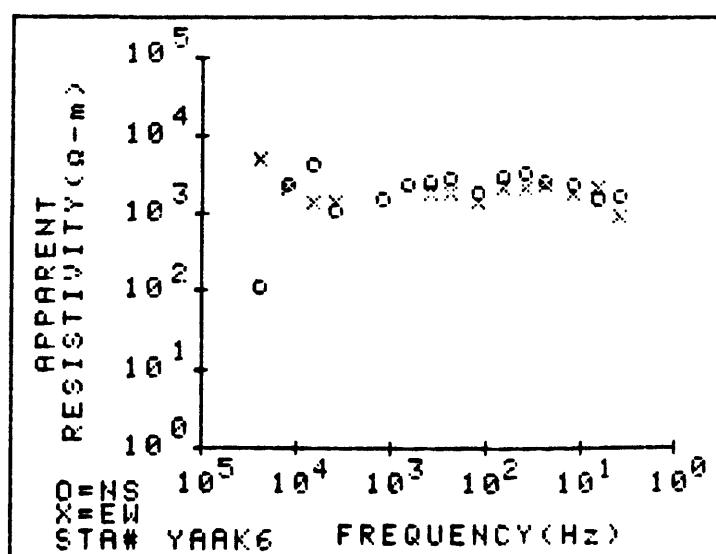
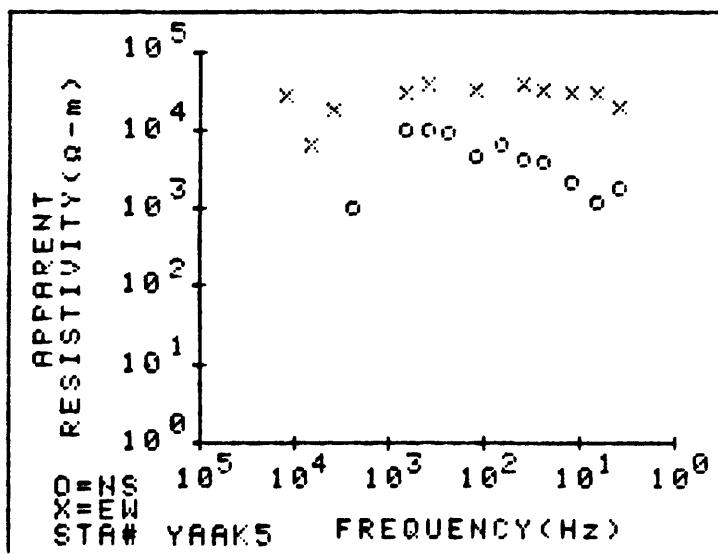


Table 1 U.S. GEOLOGICAL SURVEY A.M.T. DATA LOG- Continued

## PROJECT=YAAK RIVER

STA. ID\_YAAK7 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	113.79	7	25.76
7.5	257.09	6	87.79
13.6	106.19	6	13.43
27.0	226.83	11	44.35
45.0	175.08	9	28.72
75.0	228.02	11	18.38
136.0	198.87	11	22.17
270.0	480.35	12	34.97
450.0	815.43	11	38.10
750.0	1703.90	11	134.70
1360.0	1534.20	7	332.58
2700.0	3452.30	5	844.13
4500.0	463.25	6	142.08
27000.0	1439.70	3	21.73

STA. ID\_YAAK7 EW NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	726.67	5	236.09
7.5	1343.10	11	121.76
13.6	1213.00	11	99.08
27.0	1901.30	12	153.90
45.0	2220.30	11	140.31
75.0	2906.70	10	139.00
136.0	2383.40	11	132.49
270.0	3188.10	10	291.10
450.0	3315.80	5	576.54
750.0	2599.20	8	556.82
1360.0	2663.50	2	499.10
2700.0	3603.80	6	946.66
4500.0	4620.60	10	1232.70
7500.0	6495.90	12	419.45
13600.0	14632.00	8	2618.20
27000.0	11724.00	3	66.35

## PROJECT=YAAK RIVER

STA. ID\_YAAK8 NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	124.89	10	18.74
7.5	209.57	11	10.62
13.6	406.57	11	45.97
27.0	552.06	10	49.61
45.0	1143.60	10	100.24
75.0	1247.80	10	72.41
136.0	509.12	10	38.41
270.0	724.24	11	70.23
450.0	730.29	10	52.02
750.0	672.37	10	34.12
1360.0	350.38	10	14.68
2700.0	93.41	10	8.76
4500.0	370.67	11	28.39
7500.0	47.42	10	5.75
27000.0	14.90	4	.16

STA. ID\_YAAK8 EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	99.82	12	5.24
7.5	151.41	12	6.55
13.6	268.99	12	6.26
27.0	358.53	11	28.67
45.0	263.62	11	7.59
75.0	352.43	12	12.32
136.0	630.90	10	24.94
270.0	476.83	10	28.63
4500.0	176.75	10	6.06
2700.0	119.68	10	9.54
4500.0	312.66	11	38.33
7500.0	175.15	10	4.94
13600.0	207.79	10	16.38
13600.0	35.58	6	1.89
27000.0	94.25	5	.57

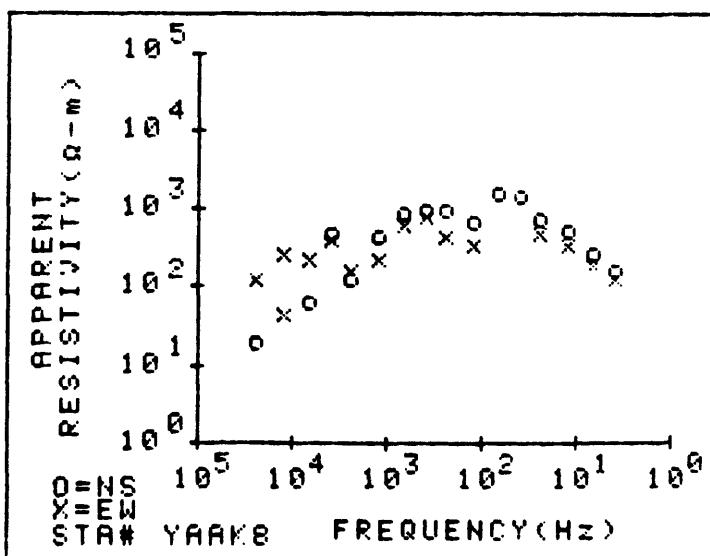
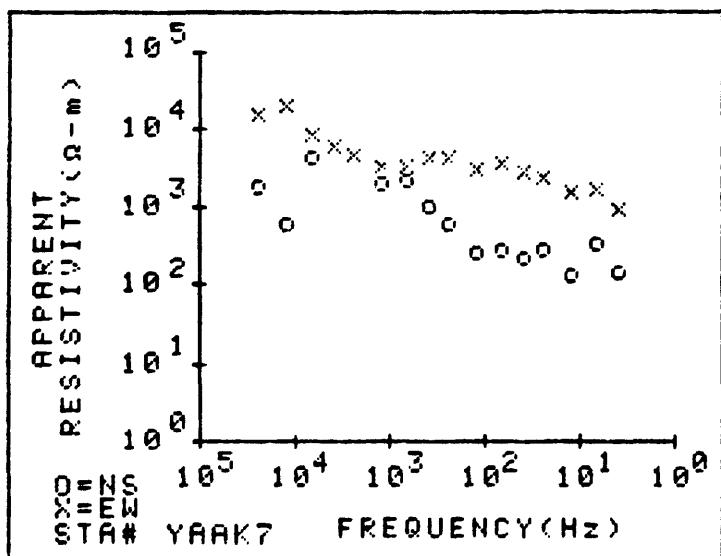


Table 1 U.S. GEOLOGICAL SURVEY A.M.T. DATA LOG- Continued

## PROJECT=YAAK RIVER-----

STA. ID\_YAAK9 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	718.16	10	74.38
7.5	1100.60	12	153.14
13.6	1089.70	10	113.84
27.0	1338.90	10	74.79
45.0	1939.60	12	115.19
75.0	2442.20	11	120.94
136.0	866.33	13	34.69
270.0	1313.80	12	83.07
450.0	2915.20	9	201.20
4500.0	931.75	10	85.79
7500.0	1286.50	11	278.34
13600.0	589.12	13	46.87
27000.0	92.66	3	.48

STA. ID\_YAAK9 EW NO FREQ= 7

FREQ	AP-RES	N OBS	STD ERR
4.5	2528.00	12	172.31
7.5	3349.10	10	340.33
13.6	4304.70	11	425.94
27.0	3664.40	11	404.96
7500.0	1486.30	10	133.01
13600.0	2796.50	10	187.71
27000.0	2609.50	4	52.53

## PROJECT=YAAK RIVER-----

STA. ID\_YAAK10 NS NO FREQ= 8

FREQ	AP-RES	N OBS	STD ERR
4.5	895.32	12	78.70
7.5	1337.00	10	105.18
13.6	1775.70	10	249.90
27.0	2913.00	10	484.98
4500.0	6554.10	9	534.06
7500.0	427.59	10	31.19
13600.0	92.31	7	24.36
27000.0	70.46	4	.98

STA. ID\_YAAK10 EW NO FREQ= 7

FREQ	AP-RES	N OBS	STD ERR
4.5	1557.50	10	121.24
7.5	1802.80	11	100.35
13.6	2109.10	12	65.46
27.0	2527.30	12	140.06
4500.0	3747.00	10	534.37
13600.0	1283.40	8	213.86
27000.0	5443.20	4	117.21

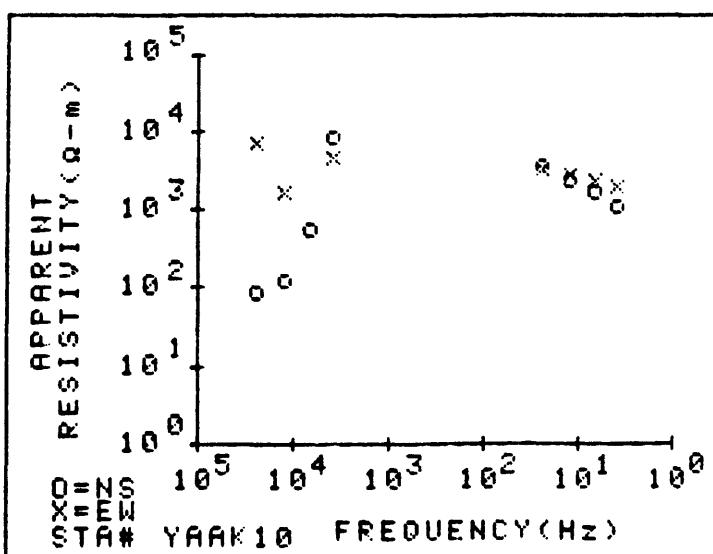
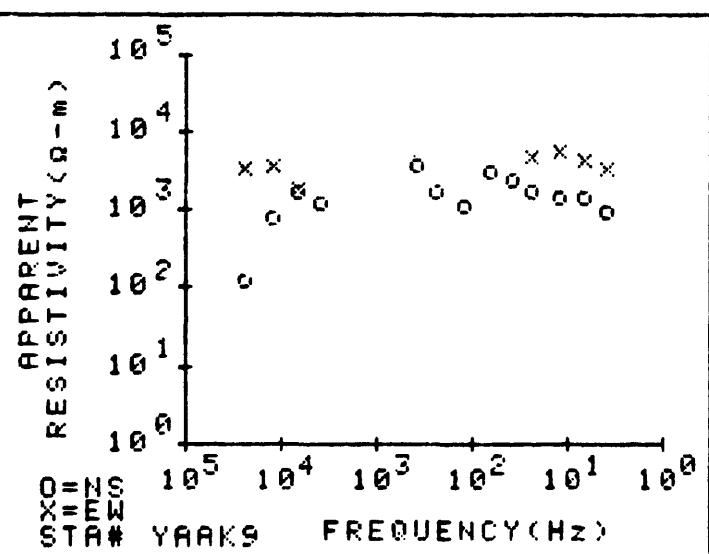


Table 1 U.S. GEOLOGICAL SURVEY A.M.T. DATA LOG- Continued

## PROJECT=YAAK RIVER

STA. ID\_YAAK11 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	2090.30	9	290.40
7.5	4587.00	11	498.70
13.6	4616.00	12	314.16
27.0	6545.00	10	441.98
45.0	9666.60	11	382.67
75.0	013356.00	10	684.18
136.0	4477.80	11	167.92
270.0	6458.50	11	122.72
450.0	6296.90	10	222.62
750.0	8792.00	10	2351.30
1360.0	4002.20	10	1126.70
4500.0	2967.80	10	350.65
7500.0	2119.50	10	191.85
27000.0	401.93	4	5.46

STA. ID\_YAAK11 EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	777.75	10	58.04
7.5	1104.00	10	106.98
13.6	1473.80	10	56.62
27.0	2133.40	11	98.87
45.0	3471.70	10	135.77
75.0	4517.90	10	284.14
136.0	2521.40	11	196.15
270.0	5208.60	10	541.71
450.0	5431.90	10	374.67
750.0	5162.50	10	386.03
1360.0	1476.40	10	76.72
4500.0	3194.10	12	627.96
7500.0	1961.10	10	144.34
13600.0	3992.30	10	251.28
27000.0	4361.10	3	24.82

## PROJECT=YAAK RIVER

STA. ID\_YAAK12 NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	690.26	12	50.80
7.5	648.48	10	45.99
13.6	814.68	10	32.54
27.0	1275.40	11	85.20
45.0	1104.40	10	24.78
75.0	1156.30	10	11.34
136.0	753.11	11	25.11
270.0	1690.10	14	54.88
450.0	1192.30	11	42.86
750.0	841.14	7	27.88
1360.0	598.95	7	60.96
4500.0	3531.10	5	690.40
7500.0	467.71	10	82.18
13600.0	135.70	6	35.44
27000.0	32.36	3	21

STA. ID\_YAAK12 EW NO FREQ= 9

FREQ	AP-RES	N OBS	STD ERR
4.5	1189.10	12	147.75
7.5	2057.10	10	109.31
13.6	2457.70	11	154.09
27.0	3438.70	10	298.16
136.0	2017.60	10	171.41
2700.0	511.44	9	87.28
7500.0	818.08	11	38.43
13600.0	803.89	10	45.63
27000.0	1257.30	3	2.58

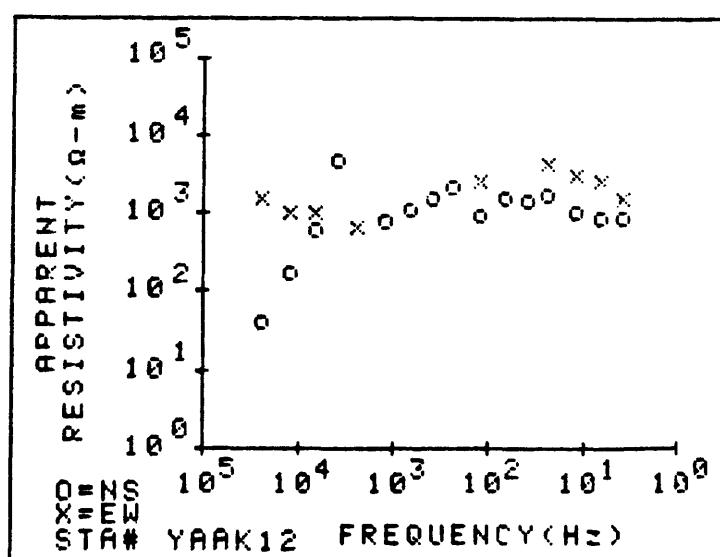
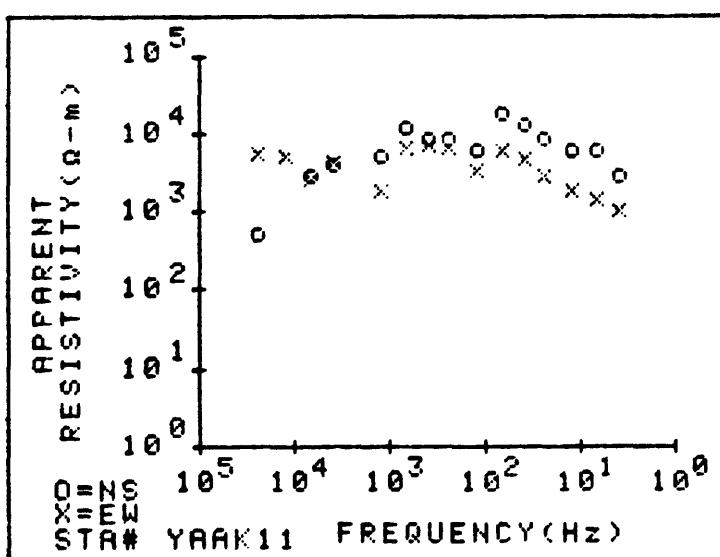


Table 1 U.S. GEOLOGICAL SURVEY A.M.T. DATA LOG- Continued

PROJECT=YAAK RIVER

STA. ID\_YAAK13 NS NO FREQ= 16

FREQ	AP-RES	N OBS	STD ERR
4.5	230.89	10	18.01
7.5	680.33	10	68.00
13.6	736.18	10	97.23
27.0	735.57	10	47.06
45.0	703.39	10	100.48
75.0	652.38	10	46.11
136.0	629.76	11	273.46
270.0	620.28	10	78.73
450.0	404.32	10	65.79
750.0	878.58	10	104.94
1360.0	761.11	10	110.15
2700.0	305.52	10	54.59
4500.0	2479.40	10	497.62
7500.0	496.70	10	66.71
13600.0	7290.00	10	296.18
27000.0	6853.20	3	6414.30

STA. ID\_YAAK13 EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	1940.40	9	167.56
7.5	1360.20	12	120.26
13.6	1776.90	10	253.39
27.0	1319.20	10	136.46
45.0	1342.50	10	97.05
75.0	1207.90	10	77.69
136.0	624.02	10	47.60
270.0	1145.10	10	285.75
450.0	1083.20	10	98.30
750.0	770.65	10	75.41
1360.0	958.64	10	213.61
2700.0	1284.70	10	148.78
2700.0	905.39	5	301.21
4500.0	1827.80	10	157.85
13600.0	3132.00	10	192.17

PROJECT=YAAK RIVER

STA. ID\_YAAK5A NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	1923.30	10	198.98
7.5	1796.20	11	224.12
13.6	3723.60	10	224.13
27.0	5865.60	11	589.94
45.0	6915.50	12	497.17
75.0	6815.60	10	895.40
136.0	5481.40	12	486.04
270.0	8658.90	11	811.42
450.0	16296.00	11	631.27
750.0	7943.60	11	500.90
1360.0	5971.70	11	557.94
4500.0	6847.10	10	1685.50
7500.0	3077.50	11	850.74
13600.0	295.68	9	61.07
27000.0	8735.30	3	45.38

STA. ID\_YAAK5A EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	11007.00	11	1248.00
7.5	521848.00	11	1883.00
13.6	620536.00	10	1030.10
27.0	21728.00	11	1112.20
45.0	222546.00	14	995.43
75.0	24472.00	11	722.31
136.0	19888.00	10	1511.50
270.0	1290.70	11	62.51
450.0	19966.00	10	1678.70
750.0	15835.00	10	1155.40
1360.0	10963.00	10	662.74
2700.0	7901.10	11	495.35
4500.0	6774.40	10	544.48
7500.0	4219.10	10	657.93
27000.0	468.33	3	4.51

